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APPLICATION FOR UNITED STATES LETTERS PATENT

for

METHOD AND APPARATUS FOR FUEL ADDITIVE DISPENSING

by

ROBERT STOUT
JONATHAN GUTHRIE
CHRIS DUHON

"EXPRESS MAIL" MAILING LABEL

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RELATED APPLICATION

Pursuant to 37 C.F.R. § 1.78, this application claims the priority of provisional application Serial Number 60/123,627 filed on March 10, 1999, the content of which being hereby incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

The present invention relates generally to the dispensing of fuel additives, and more particularly to a system for adding fuel additives into a fuel refueling stream at a fuel dispenser.

BACKGROUND OF THE INVENTION

The present invention relates to the addition of fuel additives into the fuel refueling stream at a fuel dispenser, simultaneous with a customer refueling his/her automobile in an otherwise normal manner.

Fuel additives are well known in the art. Such additives are typically petroleum-based or synthetic chemical products that can be formulated to address specific driving or automotive performance issues when added to gasoline or diesel fuels. Examples of the benefits of such additives include helping to clean fuel system components, enhancing overall engine performance, improving fuel economy, reducing emissions and preventing freezing of fuel lines in cold weather conditions.

Fuel additives are commonly blended into fuels at bulk loading terminals, for eventual retail sale through fuel dispensers as so-called "blended products." Treat rates (i.e., the concentration levels) for such additives are low, as additization levels are primarily intended to enable the fuel to meet minimum EPA regulatory requirements. In response to the known benefits of fuel additives added to fuels in more concentrated levels, a market has developed over time for bottled after-market additives. Such additives can enable treat rates many times that of pre-blended additives, and, as a result, greatly enhance cleaning, performance and other benefits to consumers.

The purchase and use of bottled after-market additives can be an inconvenient, messy, and cumbersome process. Bottled additives must be purchased from a retail store and manually poured into the vehicle fuel tank prior to refueling. This process is often smelly and messy, as liquid can spill on the car or a consumer's clothing as the additives are being poured into the vehicle fuel tank. Customers must also decide the quantity of the bottle of additive required, based on the amount of fuel to be dispensed and recommended additive treat rates.

Until they are properly discarded, partially-used additive containers are often left to roll around in the back seat or trunk of a vehicle, and can leak if bottles or cans are not properly secured. These aspects of the purchase and use of such additives are believed to have limited the market for such products.

Various methods to facilitate the blending of fuel additives into fuels at fuel dispensers have been addressed in prior art. For example, U.S. Patent No. 4,131,215 to Hansel and U.S. Patent No. 5,163,586 to Zinsmeyer propose fuel dispensers with additive dispensing capabilities in which a fuel additive may be dispensed along with fuel, and the cost of the fuel plus additive combined to result in one blended price to the consumer. These technologies appear to be applicable only to newly manufactured fuel dispensers. In addition, such technologies would seem to require extensive redevelopment and upgrading of existing station fuel dispensers and point-of-sale systems to support the functionality required for fuel additive injection at fuel dispensers. As such, the aforementioned patents do not seem to address the need for technology for upgrading (i.e., retrofitting) existing fuel dispensers in the field.

U.S. Patent No. 5,018,645 to Zinsmeyer proposes a fuel additive dispensing system separate from the fuel dispenser, in which additives are be blended into dispensed fuel, with the cost and amount of additive being displayed separately from that of the fuel. This technology involves a method for separating the fuel additive dispensing unit from the fuel dispenser. However, there remains a need in the art for technology that can be physically attached to any make or model of fuel dispenser, which can support full integration with existing station point-of-sale systems without the need for redevelopment or extensive upgrading of such point-of-sale systems, and which can support the multiple modes of customer selection, operation, and payment that is desirable for operating fuel additive dispensing systems.

Various technologies have also been shown in prior art for metering and blending of additives into fuels. For example, U.S. Patent No. 4,253,436 to Dudrey proposes a system that includes a control unit for delivering a predetermined quantity ratio of additive to the amount of fuel pumped into a particular tank. U.S. Patent No. 4,621,593 to Rao et al. proposes an apparatus for dispensing an additive into a fuel tank in dependence upon the level of fuel within a fuel tank. U.S. Patent No. 5,251,785 to Hayden proposes a method of using electromagnetic energy transmitted through a window to blend additive into a flow stream at a controlled rate. U.S. Patent No. 5,331,994 to Bryan proposes a system in which a minimum of three fuel level readings taken at fixed periods can be used to control the operation of an additive dispensing pump and maintain additive at a predetermined additive concentration with respect to the fuel.

U.S. Pat No. 5,441,072 to Indey, et al. proposes a method of dispensing additive at a variable rate corresponding to monitored variations in fuel flow rate. Finally, various technologies have been proposed for controlling the addition of an additive to the fuel while an engine is running through use of on-board additive tanks; U.S. Patent No. 4,727,827 to Hoffman et al. and U.S. Patent No. 5,195,466 to Schulte et al. are two examples of this.

In general, while each of these prior technologies addresses methods and processes that may support the injection of fuel additives at fuel dispensers, testing and evaluation of various metering methods indicates that there remains a need in the art for the development of metering technology suitable for the injection of fuel additives at fuel dispensers.

SUMMARY OF THE INVENTION

In view of the foregoing and other considerations, the present invention relates to a fuel additive dispensing system for a vehicle refueling station that enables customers at fuel dispensers to conveniently purchase and automatically blend supplemental fuel additives with their fuel during an otherwise normal refueling process. Further, the present invention enables a customer to pay for the additives in the same form and manner as that of their fuel and/or other purchase items.

The disclosed invention includes several key components, including one or more additive storage tanks and flow lines, one or more fuel additive dispensing units that attach to existing (or new) fuel dispensers and provide fuel additive service to one or both sides of said fuel dispensers, electronic control and microprocessor components incorporated into each fuel additive dispensing unit that monitor customer actions and adjacent fuel dispenser conditions including grade of fuel selected and fuel flow volumes, hydraulic metering and injection equipment incorporated into each fuel additive dispensing unit that enable the injection of precise volume increments of fuel additives corresponding to successive, selectable volume increments of fuel, audiovisual display screens incorporated into each fuel additive dispensing unit that provide product and transactional information to customers through state-specific audiovisual sequences, and network computer control equipment that provides centralized control for fuel additive dispensing unit operational and transactional processes and enables fuel additive transactions to be integrated with corresponding fuel transactions for customer payment in the same form and manner as that of the fuel and/or other purchases.

For a field system installation, fuel additive dispensing units are attached to one or more fuel dispensers at a fueling station site. One dispensing unit can provide service to one or both sides (i.e. both fueling position locations) of a single fuel dispenser, and enable the choice of one or more types of additive products to customers. In accordance with one embodiment of the invention, a dispensing unit may be physically connected to the fuel dispenser through multiple physical, hydraulic, and electronic interconnections, through the use of various housings, flanges, and electronic cables that may vary based on the fuel dispenser make and model. Each dispensing unit at a site is also connected to two additional systems: one or more additive storage and pressuring systems that provide supplies of fuel additives to each dispensing unit, and a central network server that directs operational and transactional activities of all dispensing units located at a site. In accordance with another aspect of the invention, access to storage and pressuring means may variously be either internal or external to each

dispensing unit, and the central network server may be either a stand-alone system or integrated within the body of the existing station point-of-sale system. The system design and manner of physical integration at a site enables existing fueling stations to be upgraded to include fuel additive dispensing capabilities without the need for extensive redevelopment, remanufacture, and reinstallation of the existing fuel dispensers or point-of-sale systems.

The primary interface between the invention and customers at fuel dispensers is through a graphic display integrated into the fuel additive dispensing unit. Such display is preferably located within the customer's normal field of vision with respect to the fuel dispenser, and can be canted toward the customer at an angle, to facilitate visibility and use. The display and accompanying electronic and computer control systems enable the dispensing unit to monitor operating and transactional information on the invention and the adjacent fuel dispensing equipment on a real-time basis, including grade of fuel selected and fuel flow volume. Further, the display and electronic systems are preferably capable of simultaneously displaying multiple types of text, graphics, and transactional information in different areas of the display screen.

A display system associated with the dispensing in accordance with the present invention can preferably display running totals for the purchase of fuel additives by itself or simultaneous with the display of other information, and provide interactive, state-specific, graphical and/or textual display information to customers, such that each of any number of additive dispensing systems at a site can display separate display content for each customer, thereby responding to specific modes of customer activity or equipment conditions at either the additive dispenser or the adjacent fuel dispenser. Preferably, the display and associated electronic system can send and receive transactional information required to support customer payment in the same form and manner as for the fuel or other purchases. In one embodiment, the video display may include an audio speaker to support the presentation to customers, and a proximity detector that can sense the presence of a customer or automobile so that video and/or audio content can be initiated or changed as a customer approaches the fuel dispenser.

Each fuel additive dispensing unit located at a site can interconnect either at the fuel dispenser with electronic circuitry that enables additive transactions to be integrated with the fuel transactions through the existing retail point-of-sale system, or via network computer communication (traditional cable or RF, for example) to a separate, stand-alone computer network server which functions as a central network control hub separate from the station retail point-of-sale system. Interactions between a central network server and each dispensing unit support the various transaction authorization, control, processing, data storage, and video

display functions that are necessary for invention operation. In addition, the central network server also interfaces with the existing retail station point-of-sale system to enable fuel additive transactions to be matched with the corresponding fuel transactions and facilitate payment of the additives in the same form and manner as for the fuel or other purchases.

In accordance with one aspect of the invention, consumer use of the system is quick, easy, and convenient. Consumers view product related information on the display screen included in the dispensing unit before and during the normal refueling process. This feature provides an optimum means of educating and informing a customer regarding the features and benefits of the additive products offered, as well as how to make and pay for a selection. If a customer does not wish to purchase an additive, the refueling transaction proceeds as normal. If, however, a customer does desire an additive, the system enables the customer to select among one or more types of additives, and, notably, to make a selection at any point during the refueling process. The customer merely presses a button located on the dispensing unit (typically on or near the display screen) to make a product selection. The invention also supports the ability of consumers to make an additive selection inside the fueling station or at a kiosk if it is desired to prepay for fuel and additive prior to the fuel transaction. Finally, in alternate embodiments product information and product selections may be made on the fuel dispenser, through electronic communications with the dispensing unit and the central network server.

Once a selection is made, computer-controlled electronic and hydraulic systems monitor fuel dispenser activity on a real-time basis, such that precise volume increments of the selected additive may be injected directly into the fuel refueling stream, commensurate with successive volume increments of fuel dispensed. Additive increments can be varied through configurable software logic adjustments, made either at compile time or through the provision of software options. In addition, dispensing can proceed in one of three modes of injection: In one embodiment, all dispensed fuel is treated with additive without regard to when an additive selection is made. Alternatively, only fuel dispensed subsequent to when an additive selection is made may be treated with additive. As another alternative, a preset volume of additive may be injected regardless of the volume of fuel dispensed. Following a transaction, each dispensing unit transfers additive sales data through the central network server to the station point-of-sale system so as to enable customers to pay for the additive purchased in the same form and manner as that of their fuel or other purchases: either at the fuel dispenser (via payment system integrated into the dispenser) or inside the store or at the kiosk. In the case of prepaid

transactions, such transfer of post-transaction additive sale data may be preceded by the transfer of additive authorization data prior to the sale.

The present invention advantageously enables fuel retailers and/or automotive consumers to select and add fuel additives into the fuel refueling stream at the fuel dispenser while an automobile is being refueled in the normal manner. Further, the present invention advantageously enables the cost of such additives to be integrated with the corresponding fuel transactions so as to enable customers to pay for the additive purchased in the same form and manner as that of their fuel or other purchases. Moreover, in accordance with a further aspect of the invention, existing stations may be upgraded (i.e., retrofitted) to include additive dispensing capabilities in accordance with the principles of the present invention without the need for extensive reengineering, remanufacture, and reinstallation of the existing fuel dispensers or point-of-sale systems.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features and aspects of the subject invention will be best understood with reference to a detailed description of a specific embodiment of the invention, which follows, when read in conjunction with the accompanying drawings, in which:

Figure 1 is an exploded view of a conventional fuel dispenser and a fuel additive dispensing unit in accordance with one embodiment of the invention;

Figure 2 is a partially cut-away view of the fuel additive dispensing unit from Figure 1;

Figure 3. is a partially cut-away view of a fuel additive dispensing unit in accordance with an alternative embodiment of the invention;

Figure 4 is an illustration of a display and control module from the fuel dispensing unit of either the embodiment of Figure 1 or the embodiment of Figure 2;

Figure 5 is a state diagram representing operational states and events occurring in a fuel and fuel additive dispensing system in accordance with one embodiment of the invention;

Figure 6 is a state diagram representing operational states and events occurring in a fuel and fuel additive dispensing system in accordance with an alternative embodiment of the invention; and

Figure 7 is a block diagram of a fueling station showing the general manner in which each invention unit can be connected to a central network computer server, and a schematic of the primary communication linkages between a typical fuel dispenser, the invention, the central network server, and the station point-of-sale system.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention makes use of and integrates two principal technologies: fuel dispensing systems and computer-based electronic control systems. In the disclosure that follows, in the interest of clarity, not all features of actual implementations are described. It will of course be appreciated that in the development of any such actual implementation, as in any such project, numerous engineering and programming decisions must be made to achieve the developers' specific goals and subgoals (e.g., compliance with system- and business-related constraints), which will vary from one implementation to another. Moreover, attention will necessarily be paid to proper engineering and programming practices for the environment in question. It will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the fields of computer and control system design and fuel dispensing technology having the benefit of this disclosure.

Referring to Figure 1, there is shown a fuel dispensing system 100 incorporating a fuel additive dispensing unit 102 in accordance with one embodiment of the invention. It is to be understood that Figure 1 is a partially exploded view, in that it shows the general manner in which the disclosed embodiment of a fuel additive dispensing unit 102 is attached to the side of a fuel dispenser 104 (sometimes referred to in common parlance as a "gas pump") by removing existing fuel dispenser side panel 106 and bolting or otherwise affixing dispensing unit 102 onto the side of fuel dispenser 104 at the prior location of the dispenser side panel 106. The installation process is reflected by arrows 108 in Figure 1 indicating how additive dispensing unit 102 is directed toward fuel dispenser 104 during an installation procedure. In the disclosed embodiment, the rigid (e.g. steel) external housing of dispensing unit 102 is sized and shaped so as to complement the configuration of the side of fuel dispenser 104, making the mating of dispensing unit 102 with fuel dispenser natural and aesthetically inconspicuous. Further, fuel dispenser side panel 106 may be reattached to the exterior side of dispensing unit 102, so as to preserve existing color schemes, brand name logos, and the like.

In the presently preferred embodiment of the invention, fuel dispensing unit 102 is adapted to be attached to the side of fuel dispenser 104, although it is to be understood that other configurations may be adopted, and that in alternative embodiments, dispensing unit 102 may be configured to be attachable at locations on dispenser 104 other than the side thereof. In one embodiment, dispensing unit 102 comprises a rigid (e.g., steel) housing.

Several additional connections are made between dispensing unit 102 and fuel

dispenser 104 to complete the physical installation. First, electronic cable(s) (not shown in Figure 1) from dispensing unit 102 are connected to cables emanating from each of the fuel flow meters and nozzle lift indicators inside fuel dispenser 104. Such connections enable electronic and computer circuitry inside dispensing unit 102 to monitor fuel flow rates on a real-time basis through monitoring of pulses or other outputs of the fuel flow meters, as displayed on fuel dispenser 104 on a display designated with reference numeral 141 in Figure 1. In addition, such connections also enable the electronic and computer circuitry of dispensing unit 102 to monitor the grade of fuel selected by the customer and the initiation and termination of fueling transactions on a real-time basis, as such events are conducted by a customer at a nozzle location 112 or other location.

Regarding display 140, it is contemplated that numerous known display technologies, including without limitation, liquid crystal display (LCD) screens, video display screens, and the like, will be suitable for the purposes of practicing the present invention. It is believed that those of ordinary skill in the art having the benefit of the present disclosure will be readily able to implement a suitable display 140 for the purposes of the invention as described herein.

In the disclosed embodiment, such electronic cable(s) use multiple pin connectors in which the electronic cable(s) from dispensing unit 102 tie in to cable(s) inside fuel dispenser 104 emanating from each of the fuel flow meters and nozzle lift indicators. Such cables(s) are of various types, as necessary to fit each of various makes and models of fuel dispensers 104. All such cable(s) are integrated into fuel dispenser 104 in a manner so as not to interfere or alter normal fuel dispenser operation. In an alternate embodiment, such interconnections of dispensing unit 102 with the fuel flow meters and nozzle lift indicators inside fuel dispenser 104 are accomplished via linkage to an interface box or other system that separately monitors and enables access to data and information regarding fuel dispenser activities and operating conditions.

Second, electronic cables from dispensing unit 102 connect to an electrical junction box (not shown in Figure 1) inside fuel dispenser 104 in a manner to enable dispensing unit 102 to receive electrical power from fuel dispenser 104.

Finally, fuel additive product flow lines emanating from dispensing unit 102 connect to each of the fuel flow lines inside the dispenser 104 at a convenient point such as that designated generally with reference numeral 114 in Figure 1, downstream of each fuel flow meter. In this way, fuel additives can be injected into the fuel refueling stream at fuel dispenser 104 downstream of each fuel flow meter. At such point of interconnection 114, check valves

and/or other flow control means are used to prevent reverse flow of fuel or additive through fuel dispenser 104 or the fuel additive flow lines inside dispensing unit 102. With regard to the check valves, in the presently preferred embodiment, a model 2232T1-2MM check valve commercially available from Circle Seal Controls, Inc., Corona, California is believed to have the desired combination of internal components, pressure rating, and durability for the purposes of the present invention.

Those of ordinary skill in the art will appreciate that the means of such interconnection 114 may be via custom-designed flanges, injection ports, or other suitable means, depending on requirements for each various make and model fuel dispenser 104. It is believed that the exact nature of the interconnection is not critical for the purposes of the present disclosure, beyond what has been stated above.

In various alternate embodiments, connections of fuel additive flow lines from dispensing unit 102 to fuel flow lines inside fuel dispenser 104 may be made at a point upstream of the fuel flow meters. In addition, dispensing unit 102 may alternatively be configured and attached to fuel dispenser 104 in a variety of manners and at various locations. It is believed that those of ordinary skill in the art having the benefit of the present disclosure will recognize and appreciate these and many other such design options and alternatives which may differ from implementation to implementation.

Turning now to Figure 2, there is shown a partially cut-away view of dispensing unit 102 in accordance with the presently disclosed embodiment of the invention. In the embodiment of Figure 2, a fuel additive storage and pressuring unit 116 is located exterior to the body of dispensing unit 102. In this embodiment, a customer at fuel dispenser 104 would view display content on a display and control module 110 associated with dispensing unit 102, and make a selection at any point during the fueling transaction, for example by pressing a selection button such as button 117 in Figure 2 adjacent to or on display and control module 110. After a selection is made by the customer, electronic and computer circuitry integrated into the display and control module 110 of the invention senses such selection.

In the presently disclosed embodiment, display and control module 110 comprises electronic circuitry for controlling the display content of display 140, and further comprises circuitry and user interface means (e.g., buttons, touch-sensitive displays, and the like) for enabling a customer to select one or more options associated with the dispensation of fuel additives. It is believed that those of ordinary skill in the art having the benefit of the present disclosure would be readily able to implement the electronics associated with display and

control module 110 to achieve the functionality described herein; accordingly, the specific implementation details for display and control module 110 are described herein primarily in functional terms.

As will be hereinafter described in further detail, in accordance with one aspect of the invention display and control module 110 may be responsive to user interaction either before or during a fueling operation to initiate the dispensation of fuel additive into the stream of fuel dispensed from dispenser 104. This is believed to be a particularly advantageous aspect of the invention, since it enables the customer to initiate the dispensation of fuel additive even after a fueling process has begun.

A hydraulic module for controlling the flow of additive that is dispensed is designated generally with reference numeral 118 in Figure 2. After an additive selection is made by a customer, or indicated based on other criteria, fuel dispenser conditions are monitored through electronic cables designated with reference numeral 120, and electronic signals are sent through electronic cables 122 to direct the operation of input manifold(s) 123 and output manifold(s) 124 that are disposed within hydraulic module 118. Such operation causes the selected fuel additive product to flow from the additive storage means 116 by way of the pressure generated by a pump 126 into dispensing unit 102 through additive flow lines 128, safety breaks 130, and filtration means 132, into and through an additive flow meter 134 integrated into hydraulic module 118, and then into the appropriate additive flow line 136. This in turn causes the selected fuel additive to be injected into the appropriate fuel flow line inside fuel dispenser 104. In one embodiment, pump 126 may be selectively turned on and off by electronic signals generated by display and control module 110.

Hydraulic module 118 in the presently disclosed embodiment provides fuel additive service to one or both sides of fuel dispenser 104 (i.e. both fueling positions), and in one embodiment is comprised of one or more sets of inlet flow control manifolds 123 and outlet flow control manifolds 124, upstream and downstream, respectively of a positive displacement flow meter 134. Each inlet manifold 123 incorporates one solenoid valve for each additive product. Each outlet manifold 124 incorporates one solenoid valve for each gasoline hose 113 plus one solenoid valve that allows flow to be redirected through a calibration testing line 125 for the purposes of volume accuracy testing. (As used herein, the term gasoline hose 113 will be used to refer to the familiar, typically flexible rubber hose having a nozzle at its distal end for manual insertion into the fuel tank of a customer's automobile. On the other hand, it is intended that the term "hose" as used herein shall be interpreted broadly to encompass any means by which

gasoline is dispensed from dispenser 104 into an automobile's gas tank, including all presently known such means and any means to be developed in the future.)

The terminus end of calibration testing line 125 includes a check valve (not shown) and a valve (also not shown) for control of flow testing and subsequent sealing by weights and measures officials. In the presently preferred embodiment, the check valve on calibration testing line 125 is a model SS-CHM4-10 valve commercially available from Swagelok Inc. The SS-CHM4-10 has been found to maintain a positive seal after closure, advantageously leaving consistent volumes of additive in the calibration line. This is believed to be desirable for maintaining consistent volume accuracy readings for weights and measures testing.

In operating mode, an upstream solenoid valve on an inlet manifold 123 is actuated corresponding to an additive selected by a customer, and a downstream solenoid valve on an outlet manifold 124 is actuated corresponding to the grade of fuel selected by the customer.

In calibration mode, an upstream solenoid valve on an inlet manifold 123 corresponding to an additive selected by an operator or testing official is actuated. A downstream solenoid valve on an outlet manifold 124 is actuated such that additive flow is redirected through calibration testing line 125.

Those of ordinary skill in the art will appreciate that in alternate embodiments, various combinations of manifolds, solenoid valves, flow meters, or calibration lines could be used to provide service to one or both sides of the fuel dispenser. Additionally, although the present disclosure speaks in terms of one or more discrete hydraulic "modules" 118, this is done solely for the purposes of ease of collective reference. It is to be understood that the various hydraulic elements (manifolds, solenoids, flow control meters and the like) comprising hydraulic modules 118 may not be implemented in the form of discrete units physically segregated from other components of the overall system, but instead may be physically distributed and located in different positions with respect to dispensing unit 102 and dispenser 104, as implementation requirements dictate. It is intended that the term "hydraulic module" as used herein shall encompass any arrangement of the various hydraulic control elements necessary for performing the flow control functions described herein.

In the presently disclosed embodiment, manifolds 123 and 124 are conventional off-the-shelf components such as the No. 82626G208 solenoid valve commercially available from Automatic Switch Company (ASCO), Florham Park, NJ (http://www.ascovalve.com). ASCO uses the designations HP 274387, HP 274388, and HP 274401 to refer to configurations of 8262G208 valves and manifolds presently preferred for the purposes of practicing the present

invention.

Flow meter 134 may be the Series 210 Positive Displacement Flow Meter commercially available from Max Machinery, Inc., Healdsburg, CA (http://www.maxmachinery.com). Specifically, the presently preferred flow meter for the purposes of practicing the present invention is the Max Machinery model 214-410-000 flow meter with V884 material, in association with a Max Machinery model 284-522-000 sensor and electronics assembly for monitoring flow meter activity and emitting electronic pulses commensurate with metered volumes.

Those of ordinary skill in the art having the benefit of the present disclosure will appreciate, however, that various forms and combinations of components such as described herein can be employed in additional embodiments, such as different configurations for additive storage and pressuring means, different numbers of additive flow lines and corresponding downstream or upstream components corresponding to multiple options of additive products offered to customers, different manifold and flow meter configurations, and the use of various numbers, types, and combinations of pumps and flow meters inside or outside dispensing unit 102 to transport and accurately measure fluid volumes within the appropriate tolerances.

In operation, electronic and computer control circuitry and injection control software inside display and control module 110 enable the monitoring of customer activity and operating conditions at the fuel dispenser on a real-time basis through electronic cables 120, such that the information such as the gasoline grade selected, the initiation and termination of fuel flow, and actual fuel flow volume may monitored. For example, in one embodiment, fuel flow is monitored through the counting of electrical pulses recorded by the fuel flow meter, the number of pulses being proportional to fuel volume.

As noted above, it is believed that the specific implementation of the electronic circuitry needed to implement the functions and functionality described herein, particularly that of display and control module 110 are not critical for the purposes of the present invention, and that the design and implementation of such electronics would be a matter of routine engineering to a person of ordinary skill in the art. Accordingly, specific implementation details about the electronics in the disclosed embodiment shall not be further described herein.

As quantities of dispensed fuel are monitored, electronic signals from the electronic and computer control circuitry inside display and control module 110 through electronic cables 122 cause the appropriate combination of solenoid valves to sequentially open and close to permit volume increments of the selected additive to be transported through positive displacement flow

meters. In the disclosed embodiment, such flow meter outputs a stream of electrical pulses, in which the number of pulses is proportional to fluid volume. Since the timing sequences for the opening and closing of solenoid valves can be affected by operating temperature, fluid pressure, flow rate, valve wear, solenoid type (e.g., AC or DC), and other factors, all of which can impact metered volume, dispensing unit 102 maintains a real-time log of valve timing, cumulative additive volume injected since a predetermined starting point and target cumulative volume injected. This data is processed by computer-controlled algorithms to enable automatic sensing, correction, and ensuing adjustment of subsequent valve timing and injected volumes to optimize metering accuracy. In one embodiment, adjustment of valve timing and injected volumes can be based upon assessment of past performance of the metering system and current hydraulic conditions as detected by the various sensors in the hydraulic module. This is referred to as an "adaptive metering" functionality.

In one embodiment, such computer monitoring and control preferably achieves metering accuracy to within approximately 0.75% tolerance levels, despite the relatively low volume of additive being dispensed. That is, in the presently preferred embodiment, hydraulic module 118 is preferably capable of ensuring that the amount of additive actually injected into a fuel flow line is within 0.75% of the amount of additive selected and intended to be injected. Those of ordinary skill in the art will appreciate that such accuracy is particularly desirable given the relatively small amounts of additive that are typically dispensed during any given fueling operation. After each additive volume increment is metered, it is subsequently injected into the fuel stream through additive flow lines 136 into the fuel refueling stream at fuel dispenser 104.

Additive volume increments are preset quantities that are dispensed so as to correspond to successive predetermined volume increments of fuel dispensed. Through means of configurable injection control software and other electronic and computer control circuitry inside display and control module 110, dispensing unit 102 has the capability to inject additive in varying volume increments at any point during the fueling process, such as at the initiation of fuel dispensing or at any point during any monitored volume increment of fuel dispensed. For example, in one embodiment, dispensing unit 102 injects additive in predetermined volume increments (for example, 0.8 ounces at a time) at, for example, the beginning or the midpoint of each gallon volume increment of fuel dispensed. In alternative embodiments, a predetermined increment of additive may be injected at the beginning of each gallon of fuel dispensed, or at the end of each gallon of fuel dispensed, or at the beginning, end, or any other point during any desired increment of fuel. In still another contemplated embodiment, a single, predetermined

amount of additive, as opposed to multiple incremental amounts of additive, is injected; this can be likened to a customer purchasing a bottle of additive, for example, twelve ounces, and manually pouring it into a vehicle's gas tank.

Figure 3 is a partially cut-away view of an alternative embodiment of an additive dispensing unit 102' in which the fuel additive storage and pressuring means 116 is included within the body dispensing unit 102', rather than externally as in the embodiment of Figure 2. (It is to be understood that those elements in the embodiment of Figure 3 which are essentially identical to corresponding elements in the embodiment of Figure 2 have the same reference numerals in both of those Figures.) With the embodiment of Figure 3, customers at fuel dispenser 104 view display content on the display screen 140 associated with display and control unit 110, and make selections at any point during the fueling transaction by pressing a selection button 117 adjacent to or on the display and control module 110. After a selection is made by the customer, or indicated by other means (such as a preset additive condition on a prepaid additive sale) the electronic and computer circuitry integrated into the display and control module 110 senses such selection, and monitors fuel dispenser conditions through electronic cables 120 and directs the operation of manifolds 124 and valves in hydraulic module 118 through electronic cables 122 such that the selected fuel additive product flows from the additive storage means 116 by way of the pressure generated by pump 126 through additive flow lines 127, and filtration means 130, into and through an additive flow meter 134 integrated into the hydraulic module 118, and then into the appropriate additive flow line 136 which in turn causes the selected fuel additive to be injected into the appropriate fuel flow line inside the fuel dispenser. In one embodiment, pump 126 can be selectively turned on and off by electronic signals generated by control and display module 110 in response to a customer selection of an additive or other event indicating an additive selection made or status of a transaction. Alternatively, pump 126 may be controlled from elsewhere, as will hereinafter be described with reference to Figure 6.

The further description of the physical and operating characteristics of the embodiment disclosed in Figure 2 is identical to that of the embodiment disclosed in Figure 3. In addition, as with the potential variability or location of the components in Figure 2, additional embodiments could make use of alternate equipment configurations, including various types and combinations of the pump 126 and filtration means 130 located either under, adjacent to, on, or inside the additive storage means and other various combinations, location, or types of other components as noted for the embodiment disclosed in Figure 2. In addition, the components,

mechanism, form and manner of the use and operation of the hydraulic module 118 and the variety of methods of additive injection and all other comments relative to the hydraulic module 118 would be similar to such comments made relative to the hydraulic module 118 in connection with the description of the embodiment of Figure 2.

In the self-contained embodiment depicted in Figure 3, a suction pressure fill cap is employed to seal fuel additive and pressure means 116. In the presently preferred embodiment, this cap (not depicted in the Figures) is a model 60002 suction pressure fill cap commercially available from Central Illinois Manufacturing Company, Bement, Illinois.

Figure 4 depicts display and control module 110 in accordance with one embodiment of the invention. (Those of ordinary skill in the art will appreciate that display and control module 110 is essentially the same in the embodiments of Figures 2 and 3, respectively; hence for the purposes of the following disclosure, references to dispensing unit 102 shall be interpreted as applicable to either embodiment, unless otherwise noted.) In the presently disclosed embodiment, display and control module 110 is essentially integral with the housing of dispensing unit 102, although those of ordinary skill in the art will appreciate that display and control module may be affixed to the housing of dispensing unit 102 or fuel dispenser 104 from the housing of dispensing unit 102 or fuel dispenser 104 and connected to the internal components of dispensing unit 102 via multiple cables or wires.

As noted above, display and control module 110 preferably houses key electronic and computer components and the display screen for presenting graphical and textual information to customers. Display and control module 110 includes multiple types of electronic and computer circuitry inside a display housing which may integrated into dispensing unit 102.

In one embodiment, display and control module 110 includes a display screen 140 that is segregated into different, specific viewing areas. In the example of Figure 4, display screen 140 is segregated into three distinct viewing areas designated with reference numerals 142, 144, and 146. Each viewing area 142, 144, and 146 is assigned a given function and is under the coordinating control of a specific, independent software code set that works in tandem with the electronic and computer circuitry in the display and control module 110 to enable each screen area to display different types/formats of text or graphical content independent from content that may be displayed on the other areas of the screen 140. In the presently preferred embodiment of the invention, display and control module 110 incorporates a computer platform that is essentially a conventional personal computer class of computer. For example, display and control module 110 may comprise a computer based on the well-known Intel™ Pentium™

class of central processing unit or the like, having conventional sub-components such as memory, graphics circuitry and the like associated therewith. Those of ordinary skill in the art will appreciate, of course, that certain functions of dispensing unit 102, including those of display and control module 110, may be performed by dedicated subsystems having their own processing capabilities. Such implementation-specific considerations are not believed to be particularly critical for the purposes of appreciating the present invention. It is believed that those of ordinary skill in the art having the benefit of the present disclosure would be readily able to implement a display and control module suitable for the purposes of practicing the present invention as a matter of routine engineering.

In the disclosed embodiment, an upper left portion of the screen 142 is used to display various types of video text, graphics, advertising, promotional and/or infomercial content related to the use and operation of the system, as well as fuel additive product choices, features, and benefits. Such screen area 142 is controlled by an independent software code set and time function in which one or more video and/or audio files stored on RAM within the electronic and computer circuitry of the display and control module 110 are accessed through configurable controls and directed to be displayed on screen area 142 during a specific state for either a specific time duration or until a specific event happens. For example, such specific event may be a customer action that triggers a change to a different state. Through the use of the independent software code set and time function, the display of such video and/or audio files on screen area 142 for any state can be controlled independent of each other and independent of content that may be displayed simultaneously on other screen areas.

A bottom portion of the screen 144 is used to display static or running totals of dispensed additive volume, updated on a real-time basis for volume and sale totals for dispensed fuel additive products. Such screen area 144 is controlled by an independent software code and is event-driven on a basis independent of the other screen areas. During an additive dispensing process, dispensed volume data is monitored and/or calculated for each increment of additive dispensed, and the screen area 144 is updated on a real-time basis as such information is received.

A right side of the screen 146 is used to display fuel additive product names and prices which correspond to context-sensitive selection buttons 117 located either on or adjacent to the screen 140. Such screen area 146 is controlled by an independent software code set which enables the display to be changed/updated based on one of three specific events. First, at the end of every sale, prices and product names can be read by the electronic and computer

circuitry within the display and control module 110 from configuration files in the central network server. The right portion of the screen is changed to reflect any such price or product name change that has occurred. Second, during an additive sale, the prices and/or product names of the "non-selected" additives are blanked-off, or erased from customer's view. This enables the customer to only see information corresponding to the selected product after a selection has been made. Third, the electronic and computer circuitry within the display and control module 110 may receive a specific message from the central network server instructing it to reread price or product name information. If so, it rereads and updates such information, unless if such message is received while an additive transaction is in progress, it waits until the sale is completed to read and update such information. Through the use of such independent software code sets within the electronic circuitry of display and control module 110, each area of the screen can display different types/formats of text and graphical content either simultaneous with or independently from that displayed on the other areas of the screen 140, regardless of the content displayed in the other areas.

Display and control module 110 in the presently disclosed embodiment may further include additional components for facilitating consumer use of dispensing unit. An audio speaker 148 may be integrated into display and control module 110 to support the use of audio in conjunction the graphical content displayed on screen 140. A proximity detector 150 may also be integrated into the display and control module 150. Proximity detector 150 may advantageously be used to detect the presence of an approaching customer or automobile such that audiovisual content can be changed or initiated specifically for each customer, as the customer approaches a dispensing unit 102 or fuel dispenser 104 at the site. Proximity detector 150 may be, for example, an infrared motion sensor or the like, such as is commonly employed for the purposes of detecting a person's presence in a particular area. In one embodiment, proximity detector 150 is responsive to the detection of a person in the vicinity of dispensing unit 102 and/or fuel dispenser 104 to generate an electrical detection signal applied to said control circuitry. Upon receipt of such a detection signal, display and control circuitry 110 may, for example, alter the content of display screen 140.

Those of ordinary skill in the art will appreciate that in alternate embodiments, the audio speaker 148 and the proximity detector 150 can be moved to locations on dispensing unit 102 or fuel dispenser 104 other than those shown in the Figures, as desired in a given implementation.

Display and control module 110 may include an area 152 for a decal used to

communicate various types of information or promotional content to a customer. Finally; display and control module 110 is positioned on dispensing unit 102 at eye-level and within a customer's normal field of vision at the fuel dispenser 104, such that the module 110 is within a customer's line of sight and easy reach. For example, display and control module 30 in the disclosed embodiment is canted toward the customer at a 28° angle. In alternative embodiments, display and control module 110 can be mounted flush with fuel dispenser 102 or at higher or lower canting angles. Additionally, the display screen 140 and other components of the display and control module 110 can be integrated in a variety of a manners into the fuel dispenser 104 itself, in alternate embodiments.

As noted above, display and control module 110 incorporates one or more computers which can (1) by connection to a proximity detector 150 sense when a customer is within range of the device, (2) display various graphical and/or textual content to customers at the fuel dispenser, (3) interactively guide a customer through the selection of a product, (4) display the progress of a sale, (5) control the dispensing of a product, (6) communicate and receive a variety of authorization, sales, and transactional to and/or from a central network server.

Figure 5 is a state diagram of the state-specific display and control system logic employed by dispensing unit 102 in one embodiment of the invention. Through this system and associated electronic and computer-controlled systems integrated into dispensing unit 102, dispensing unit 102 monitors customer activity and operating conditions on a real-time basis at both dispensing unit 102 and the adjacent fuel dispenser 104. Such capability enables dispensing unit 102 to (1) change audiovisual content in response to customer activity or operating conditions on a real-time basis such that each customer at each dispensing unit 102 or fuel dispenser 104 at a site is presented with individual, position-specific audiovisual content, (2) direct and control the fuel additive injection process on a real-time basis, and (3) facilitate linkages to the various transaction authorization, control, processing, and data storage functions that are necessary for dispensing unit operation and integration of fuel additive transactions with the corresponding fuel transactions such that payment of the additives is accomplished by customers in the same form and manner as that of the fuel or other purchases.

The state-specific display system uses a finite state machine, operating on embedded computers preferably within each display and control module 110 connected by a local-area network to one or more computer servers, to simultaneously control audiovisual presentation and additive injection and control operations. The server(s) control the commercial and "back

office" aspects of the sale, such as sales authorizations, billing, and interface to the station point-of-sale system, and storage of sales data. The server(s) also maintain sales and other historical data as desired or required by the Bureau of Weights & Measures or other state or federal regulatory agencies. The computer circuitry inside display and control module 110 generates the audiovisual display for screen 140 and controls the progress of a sale. Communications between the server(s) and each display and control module 110 within each dispensing unit 102 are facilitated through use of a real-time network protocol that enables constant, real-time interactions between the server(s) and each dispensing unit 102. Each display and control module 110 may be configured to record, maintain and/or transfer event and history logs on a real-time basis for storage on a server. This supports the server(s), maintenance of sales and other historical data as desired or required by Weights and Measures or other state or federal regulatory agencies as well the ability to review past operational events for analysis of code or equipment maintenance issues. The event logging methodology uses a variable, configurable debug level in which the level and volume of detail to be retained in the event log can be specified and/or adjusted as desired. Through use of the real-time network protocol to constantly inform the server(s) of dispensing unit or transaction conditions, the server(s) in tandem with each display and control module 110 use nonvolatile storage of network client data in tandem with battery back up on the network server(s) to enable the orderly transfer, storage and restoration of nonvolatile data. Other computers may be slaved in series or in parallel to accomplish various real-time functions. The use of the finite state machine facilitates interactivity between control operations, network communications, and the audiovisual interface.

The finite state machine includes capabilities to enable transactions in a variety of operating modes; payment by cash, credit or debit card either before or after fuel is pumped, with additive volume either preset based upon specification by the customer or automatically set by dispensing unit 102 in response to volume of fuel dispensed. Within each mode of operations, dispensing unit 102 monitors customer activity and equipment conditions at both dispensing unit and the fuel dispenser. Electronic signals are processed and acted upon by various of dispensing unit's electronic and computer circuitry. The state-specific events for one operating mode within the disclosed embodiment would be as follows.

With no customer at or in the vicinity of dispensing unit 102 or the fuel dispenser 104, dispensing unit is in the idle state represented by block 156. Dispensing unit 102 remains in this idle state 156 until a customer or automobile approaches. Various types of audiovisual content

can be presented during idle state 156, such as a "screen saver" which can be seen by passing motorists. As a customer or automobile approaches dispensing unit 102 and/or fuel dispenser 104, proximity detector 150 senses their presence. Electronic signals are processed by the dispensing unit's electronic and computer circuitry and dispensing unit 102 enters into a standby state represented by block 158 in Figure 5. Various state-specific audiovisual content can be presented during standby state 158. In one embodiment, the system can be configured to bypass the idle state 156 altogether, such that a transition from the idle state 156 to standby state 158 is automatically made whenever the state machine attempts to enter idle state 156.

Standby state 158 is exited by one of three means. If an additive selection button 117 on dispensing unit 102 is pressed, a select state is initiated, as represented by block 160. More than one select state 160 may be provided, if different pre-pay modes are available, for example. Alternatively, if a fuel hook (designated with reference numeral 162 in Figure 1, for example) is activated by the customer at adjacent fuel dispenser 104, a presale state 164 is initiated. Finally, if no activity or change in equipment conditions at either dispensing unit 102 or adjacent fuel dispenser 104 is detected within a pre-selected time period, dispensing unit returns to the idle state 156.

From select state 160, various state-specific audiovisual content is presented. If the customer does not activate a fuel hook at the adjacent dispenser within a specified time period, dispensing unit returns to idle state 156. If the customer does activate a fuel hook 162 at adjacent fuel dispenser 104 within the specified time period, dispensing unit 102 enters a sale state 166. In the sale state 166, dispensing unit can present product-specific audiovisual content as it monitors fuel dispenser activity on a real-time basis, and directs and controls the precise injection of volume increments of fuel additives into the fuel refueling stream at the fuel dispenser through one of three presently contemplated dispensing modes. In a first dispensing mode, all fuel purchased is treated with additive regardless of when the additive selection was made. In a second dispensing mode, only fuel volumes that are dispensed subsequent to when an additive selection was made are treated with additives. In a third dispensing mode, a preset volume of additive is injected into the fuel, without regard to the volume of fuel dispensed.

Within each dispensing mode, dispensing unit 102 has the capability to vary the amount of each volume increment of additive or the point of injection corresponding to each volume increment of fuel. In addition, within each dispensing mode, dispensing unit 102 preferably has the capability to calculate whether or not the dispensed additive has traveled through the fuel hose and into the fuel tank. Those of ordinary skill in the art will appreciate that such capability

is achieved by monitoring, in dispensing unit 102, the flow of fuel out of fuel dispenser 104, as well as perhaps such parameters as the flow rate. Additionally, control circuitry in display and control module 110 is preferably informed as to the volume of fuel which can be contained in the system between the point of additive injection and the point at which the stream of fuel exits hose 113. With this knowledge, the control circuitry can ensure that each injected increment of additive is expelled from hose 113 before that increment of additive is accounted for (i.e., charged to the customer). This feature advantageously prevents additive volume increments that have not reached the fuel tank from being billed to the customer. In addition, dispensing unit 102 preferably has the capability to display running total sale information for the product purchased on display screen 140 either by itself or simultaneously with the display of other video content on the screen.

Once the deactivation of a fuel hook at fuel dispenser 104 is detected (indicating that the fueling transaction has ended), dispensing unit 102 enters a collect state represented by block 168 in Figure 5. Collect state 168 is a transition state in which fuel and/or additive transactional information is relayed to the central additive network server or the station retail point-of-sale system pending closing of the transaction. Once transactions are closed, dispensing unit 102 enters a post-sale state represented by block 170 in Figure 5. From this state, sale amounts and other transactional data are transferred to data storage systems, which typically would be located at the central additive network server. Following the post-sale state 45, dispensing unit automatically reenters either the standby state 158 or the idle state 156.

From presale state 164 in which a fuel hook 162 at fuel dispenser 104 is activated but no additive button 117 is selected, dispensing unit presents various audiovisual content. If a fuel hook 162 at fuel dispenser 104 is deactivated prior to an additive selection button 117 being pressed by the customer (i.e. transaction ended), dispensing unit 102 enters collect state 168, and proceeds through subsequent states as indicated. If, on the other hand, an additive selection button 117 is pressed while dispensing unit 102 is in the presale state, dispensing unit 102 can present to the user various state-specific and/or product specific audiovisual content, after entering the aforementioned sale state 166. Thereupon dispensing unit 102 proceeds through subsequent states as previously described.

Dispensing unit 102 supports variable display content in a configurable manner such that any single state on any dispensing unit 102 at a site can incorporate a wide variety of state-specific graphics types and formats, such as still slides without audio or motion video with audio. Such different types and formats can be displayed on different areas of the video display

screen simultaneously with different types and formats displayed on other display screen areas, if preferred.

The presentation of the state-specific audiovisual content and operating content sequences as described in Figure 5 is for one operating mode only (payment via cash after the fueling transaction is completed). Those of ordinary skill in the art will appreciate that multiple combinations and forms of similar state-specific process may be used for each of multiple modes of operation (e.g. post-pay cash inside, post-pay via credit card at the fuel dispenser, prepay cash or credit inside, and so on), including multiple additional states which may be added before, during, or after the states described with reference to Figure 5.

In Figure 6, there is shown a state diagram illustrating the operation of the finite state machine of dispensing unit 102 in accordance with an alternative, and presently preferred, embodiment of the invention. The operation of the state machine illustrated in Figure 6 can perhaps best be appreciated with reference to the following Table 1, which sets forth the operational status of dispensing unit 102 in each of the states. Table 1 further sets forth simple examples of the types of messages or content that might be displayed on display and control unit 110 in each of the states, it being understood that in actual implementation, such messages and content would likely be more "consumer friendly."

TABLE 1

REF. NO.	STATE NAME	DESCRIPTION	EXAMPLE MESSAGE
172	IDLE	This is the equivalent of a "screen saver" on a desktop computer, corresponding to a situation in which dispensing unit 102 has been idle for some period of time and proximity detector 150 does not detect the presence of a customer. Display and control unit 110 may display advertising content, for example.	(Screensaver)
174	STANDBY	The transition from IDLE to STANDBY occurs upon the detection of a potential customer by proximity detector 150. In this state, display and control unit 110 may display content intended to encourage the potential customer to include an additive with his or her purchase.	"Welcome."
176	PRESALE	In this state, display and control unit 110 is aware that the customer is purchasing fuel, but no additive has been selected. Display and control unit 110 may display	"Thank you for your fuel selection; would you like additive as well?"

TABLE 1

REF. NO.	STATE NAME	DESCRIPTION	EXAMPLE MESSAGE
		an inquiry as to whether the customer would like to purchase additive as well.	
178	POSTPAY	The POSTPAY state is entered when the customer has arranged to pay for fuel (and possibly additive) after fuel has been dispensed. An example of this is the familiar "Pay Inside Credit" option found on many conventional fuel dispensers. In the POSTPAY state, display and control unit 110 initiates a transaction by requesting authorization for a specific additive from the computer control circuitry (to be hereinafter described in further detail with reference to Figure 7). The computer control circuitry replies with an authorized dollar amount.	"Transaction authorized."
180	PUMP PAUSE	This state represents a pause in the operation of the state machine while fuel is being dispensed.	"Start fueling; your additive will be dispensed."
182	FUEL SELECT	This state is entered when the customer selects an additive before selecting a fuel type.	"Please select fuel before selecting an additive."
184	ADDITIVE SELECT	If display and control unit 110 is notified of a pre-paid transaction, it notifies the user to either select an additive or select no additive. For prepaid transactions, the computer control system initiates the additive transaction, and display and control unit 110 receives authorization for dispensing additive as soon as the customer begins the fueling transaction. Alternatively, display and control unit 110 can receive an authorization request which requires that an additive be selected before the sale can proceed. A customer can optionally specify "no additive."	"Is an additive desired?"
186	NO SALE	This state is entered if display and control unit 110 is notified of a pre-paid transaction that is expressly not to include additive.	(no message)
188	SALE	This state is entered when dispensing unit 102 begins dispensing additive.	"Additive is being dispensed."
190	COLLECT	This state is entered when the sale of additive is being posted to the point-of-sale system, after the dispensing of fuel and additive has completed.	"Your sale is being posted. Please make payment as arranged."
192	POST-SALE	This state is entered after the sale of	"Thank you for buying

TABLE 1

REF. NO.	STATE NAME	DESCRIPTION	EXAMPLE MESSAGE
		additive has been posted.	additive."
194	INFORMATION	The transition from STANDBY state 174 or PRESALE state 176 occurs if a customer requests information about additives.	"Here are the additives available, and this is what they do...."
196	ERROR	Several possible error conditions may arise. For example, dispensing unit 102 may be purposefully disabled. A customer's attempt to select an additive may be denied unless cash is paid in advance. The computer network controlling one or more dispensing units 102 (to be hereinafter described in greater detail with reference to Figure 7) may be inoperative, preventing the dispensing of additive. Meters and gauges within dispensing unit 102 may detect an error during the attempted dispensing of additive.	A message appropriate to the type of error occurring may be displayed. Alternatively, the message "System disabled" may be displayed.

Turning now to Figure 7, there is shown a simplified block diagram of an overall fueling station retail transaction system 200 incorporating one embodiment of the present invention. Based on the description which follows, those of ordinary skill in the art will recognize that system 200 in Figure 7 includes the principal components of current state-of-the-art retail fueling station systems, plus similar components to effect the incorporation of fuel additive dispensing capabilities in accordance with the principles of the present invention. System 200 includes one or more fuel dispensers 104 (for clarity, only one of which being shown in Figure 7) having fuel additive dispensing units 102 associated therewith (again, only one of which being shown in Figure 7). System 200 further comprises a central POS network server 210 to which each fuel dispenser 104 is connected via communication link 206. Further, POS network server 210 is coupled by communications link 209 to central additive network server 202 to which each fuel additive dispensing unit 102 is connected by a communications link 207. Communications link 209 enables the integration of fuel additive transactions with corresponding fuel transactions.

It is to be understood that communication links 206, 207, and 209 may take various forms. In some cases, communication links may be established by means of hard wiring, typical of conventional computer network configurations. Alternatively, communications links may be

established for the purposes of the present invention via wireless (e.g., radio frequency or infrared) communication channels. In any event, for the purposes of the present disclosure, it suffices to describe communications links 206 as channels by which information regarding the operational status and transaction information of each fuel dispenser 104 can be transmitted to central POS server 210, communications link 207 as the channel by which the operational status and transaction information of each dispensing unit 102 can be communicated to central additive network server 202, and communications link 209 as the channel by which operational status or transaction information of a dispensing unit 102 can be communicated to central POS server 210 by way of central additive network server 202.

Central POS server 210 is commonly part of an existing station point-of-sale ("POS") system 208. Module 212 is the "cash register" at which consumers can consummate transactions for the sale of fuel (and other items). Typically, POS system 208 is located within a store or kiosk at the fueling station. In one embodiment, POS system 208 comprises a computer 210 and user terminal 212. POS system 208 is also preferably coupled to each fuel dispenser 104 via a communications link 206 and to central additive network server 202 via a communications link 209 and by association to each fuel additive dispensing unit 102 via communications link 209

In general, each dispensing unit 102 is designed such that it can either be connected to POS system 208 through fuel dispenser 104, and/or it may be connected via network communication link 207 to central additive network server 202 supporting the various transaction authorization, control, processing, and data storage functions that are necessary for dispensing unit operation and the integration of fuel additive transactions with the corresponding fuel transactions such that payment of the additives can be made in the same form and manner as that of the fuel or other purchases. Due to the preferability of avoiding the extensive system hardware/software redevelopment that would be required to upgrade (e.g., retrofit) existing station point-of-sale systems to incorporate all required dispensing unit functionality, the disclosed embodiment contemplates the separate network control server alternative as depicted in Figure 6.

In one embodiment, each dispensing unit 102 at a site location attaches to a fuel dispenser 104 and is connected to separate central additive network server 202 such that each dispensing unit 102 sends and receives sales authorizations and transactional data primarily to and from the central additive network server 202, and each fuel dispenser 104 sends and receives sales authorizations and transactional data primarily to and from the existing point-of-

sale system 208. Both central additive network server 202 and the retail station POS system 208 are typically located inside a store or kiosk (not shown in Figure 7). In a typical configuration, both the central network additive server 202 and retail station POS system 208 use network message communications protocols or other means to communicate via links 209 respectively with each dispensing unit 102 associated with a fuel dispenser 104.

In another embodiment, each dispensing unit 102 may be provided with a credit card reader for enabling a customer to pay for fuel additive separately from the fuel itself. Those of ordinary skill in the art will appreciate that such a credit card reader may be exposed on the face of display and control module 110 to enable a user to select and pay for a desired fuel additive. Control information regarding the selection of and payment for additive may be communicated to central additive network server 202 and/or POS system 208 in the manner described herein.

In a typical operating mode configuration (payment via cash after the fueling transaction is completed), a customer lifts a nozzle 162 at the fuel dispenser 104, and fuel dispenser 104 requests authorization from POS system 208. Once authorization is received, fuel dispenser 104 begins dispensing fuel. At such point that the customer selects an additive at dispensing unit 102, dispensing unit 102 monitors such selection, and requests authorization from central additive network server 202. Once authorization is received, dispensing unit 102 dispenses additive into the fuel refueling stream at the fuel dispenser 104 during the fuel refueling process under one of three dispensing modes as previously described. After the fueling transaction is completed, fuel dispenser 104 transmits fuel sale information to POS system 208, and dispensing unit 102 transmits fuel additive sale information to central additive network server 202. By means of computer network integration, POS system 208 then receives the fuel additive sale information from central additive network server 202 such that the fuel additive sale information can be matched with and posted to the corresponding fuel sale information. In this manner, the customer can pay for the cost of the fuel additive purchase at the same time and place, and in the same form and manner, as that of the fuel or other purchases.

In another operating mode configuration (payment via cash prior to a fueling transaction being initiated in which a preset amount of additive is requested by the customer), a customer pays the cashier inside the store or kiosk and returns to fuel dispenser 104. Through computer integration means, POS system 208 sends a preset additive volume message to central additive network server 202 indicating the selected additive amount and the designated fuel dispenser 104. Central additive network server 202 authorizes the corresponding dispensing

unit 102 and such dispensing unit 102 dispenses additive into the fuel refueling stream at the fuel dispenser 104 during the fuel refueling process under one of three dispensing modes as previously described. After the fueling transaction is completed, fuel dispenser 104 transmits fuel sale information to POS system 208, and dispensing unit 102 transmits fuel additive sale information to central additive network server 202. By means of computer network integration, POS system 208 then receives the fuel additive sale information from the central additive network server 202 for ensuing processing.

In yet another operating mode configuration (payment via cash prior to a fueling transaction being initiated in which the customer is not required to specify his/her desire for an additive at the time of prepayment), a customer pays the cashier inside the store or kiosk and returns to the fuel dispenser 104. Through computer integration means, POS system 208 sends a prepay fuel volume message to the central additive network server 202 indicating the total prepaid amount and the designated fuel dispenser 104. POS system 208 also delays authorization of the appropriate fuel dispenser 104 pending receipt of a prepay allocation message from central additive network server 202. Central additive network server 202 informs the appropriate dispensing unit 102 of such prepay condition, and such dispensing unit monitors ensuing customer selections of fuel and fuel additive, and informs the central network server of such selections. If no additive is selected, central additive network server 202 sends a prepay allocation message to POS system 208 indicating that 100% of the prepaid amount should be allocated to fuel. POS system 208 then authorizes the appropriate fuel dispenser 104 for such amount. If, however, an additive is selected, central additive network server 202 uses a prepay allocation algorithm to calculate the respective amounts of fuel and additive that should be dispensed, based on the total prepaid amount, the fuel grade and additive type selected and their respective retail prices and fuel additive treat rate (i.e., the volume of additive dispensed per volume of fuel dispensed). After such calculation, central additive network server 202 sends a prepay allocation message to POS system 208 indicating the amount of the prepaid amount to be allocated to fuel. POS system 208 then authorizes the appropriate fuel dispenser 104 for such amount, and central network additive server 202 authorizes the appropriate dispensing unit 102 for the prepaid amount to be allocated to the selected additive. Dispensing unit 104 then dispenses additive into the fuel refueling stream at the fuel dispenser 104 during the fuel refueling process under one of three dispensing modes as previously described. After the fueling transaction is completed, fuel dispenser 104 transmits fuel sale information to POS system 208, and dispensing unit 102 transmits fuel additive sale information to central additive

network server 202. By means of computer network integration, POS system 208 then receives the fuel additive sale information from central additive network server 202 for ensuing processing.

In yet another operating configuration (a prepaid fuel-only transaction in which a customer specifies to the cashier that no additive is desired), a customer may prepay to the cashier. The station POS system 208 sends a message via communications link 209 informing central additive network server 202 of a fuel-only prepay transaction. In this case, central additive network server 202 "disables" the respective dispensing unit 102 for the duration of the fuel transaction.

The description of such communications and operations for the various operating mode configurations are but one of many similar processes that systems in accordance with the present invention may employ, depending on the type of point-of-sale system and the overall mode of operation (e.g. post-pay cash inside, post-pay via credit card at the fuel dispenser, prepay cash or credit inside, etc.) to direct, control, and process transactions. Such communications protocols for such communications can be via network messages or serial port communications in a variety of forms and manners, as would be familiar and appreciated by those of ordinary skill in the art. In total, systems in accordance with the present invention support a wide variety of configurations, including the inclusion or integration of some or all dispensing unit control and functional capabilities within the fuel dispenser and station POS system 208 if desired. As with this and other aspects of the invention, it will be apparent to those of ordinary skill in the art that many embodiments of the subject invention may be designed that are not described in specific detail herein.

From the foregoing detailed description, it should be apparent to those of ordinary skill in the art that a method and apparatus for dispensing fuel additives simultaneously with the dispensation of fuel in a retail setting has been disclosed. Systems in accordance with the disclosed embodiment of the invention are advantageously adapted to be incorporated into existing retail fueling station systems, and are adapted to be operable before and during the normal fuel dispensing process.

As described above, the invention in part involves the use of computer-based electronic systems, of which many personal and industrial grades and types are available. The programming necessary to implement the functionality described herein is believed to be within the capability of any competent programmer, and may be accomplished through the use of a program storage device readable by the processor that encodes a program of instructions

executable by the processor for performing the operations described above. The program storage device may take the form of, e.g., a floppy disk; a CD-ROM; a memory device (e.g., RAM, ROM, EPROM, EEPROM, etc.); and other forms of the kind well-known in the art or subsequently developed. The program of instructions may be "object code," i.e., in binary form that is executable more-or-less directly by the computer; in "source code" that requires compilation or interpretation before execution; or in some intermediate form such as partially compiled code. The program storage device may be one that is directly readable by the processor, or it may be one that is unusable by the processor per se but that provides intermediate storage of the program of instructions. The program of instructions may be read directly from the program storage device by the processor; alternatively, the program of instructions may be temporarily or permanently stored in the program storage device and transmitted from it to the processor over one or more links, e.g., over a telephone connection (such as a modem connection or an ISDN line); over a cable-modem hookup; over the Internet; via radio- or satellite transmission; etc., possibly with other program storage devices providing intermediate storage along the way. The precise forms of the program storage device and of the encoding of instructions are immaterial here.

Although specific embodiments of the invention have been described herein in some degree of detail, this has been done merely to illustrate various features and aspects of the present invention, and is not to be construed as limiting the scope of the invention as defined by the claims which follow. Those of ordinary skill in the art will appreciate that various substitutions, alterations, and/or modifications, including but not limited to those design variations and options that have been specifically noted herein, may be made to any of the embodiments of the invention disclosed herein without departing from the spirit and scope of the claims which follow.